throw light on many of the practical difficulties hitherto felt in any method of carrying out gyrostatic investigation of the earth's rotation, and which have led the author to fall back upon the method described by him at Southport, of which the essential characteristic is to constrain the frame of the gyrostat in such a manner as to leave it just one degree of freedom to move. The paper concludes with the description of a simplified manner of realising this condition for a gyrostatic compass—that is to say, a gyrostat free to rotate about an axis either rigorously or very approximately vertical.

Section C—Geology

On Ice-Age Theories, by Rev. E. Hill, M.A., F.G.S., Tutor of St. John's College, Cambridge.—On the Montreal Mountain, in the neighbouring quarries, at the mouth of the Saguenay River, and more or less everywhere over all Canada and all the north and north-west of this continent, are seen phenomena which imply a former vastly extended action of ice. The like are found over Europe and Asia, thus completely encircling the Pole. Many theories have been propounded to account for these facts. It is proposed to pass these before you in review. Any explanation ought to account not only for cold greater than the present, but for accumulations of snow and ice. A kindred phenomenon is the greater size of the Antarctic ice-cap. The supposed interglacial warm periods, and the unquestioned luxuriance of Miocene vegetation in Greenland, ought also to find their causes in any thoroughly satisfactory theory. The theories which have been propounded fall into three groups, as Cosmical, Terrestrial, and Astronomical (or Periodical). The Cosmical theories are Poisson's Cold-Space theory—incomprehensible; and the Cold-Sun theory of S. V. Wood and others—lacking any evidence. The Terrestrial theories are numerous. Lyell's suggestion of Polar-continent and Equatorial-ocean is opposed by evidence that continents and oceans lay on much the same areas as now. The contrary view, Polar-ocean and Equatorial-land, would deserve consideration but for the same opposing evidence. The elevation view (Dana, Wallace), which alleges greater altitude of mountain-chains, disagrees with the strong evidence for land-depression during the period. The submergence view of Dr. Dawson agrees with this evidence, but requires elucidation. Alteration of ocean-currents (Gunn, J. S. Gardiner) is a most powerful agency, but would act locally rather than universally round the Pole. Alteration of prevalent winds, hitherto worked out by no one, deserves attentive consideration. Conditions are conceivable which would produce over an area winds from cold quarters almost permanently. However, this seems open to the same objection as the preceding theory. Last come the Astronomical or Periodical theories. A tilt of the earth's axis was suggested by Belt, but suggested as owing to causes which are wholly insufficient. Tilting from astronomical agencies is slight, though its action would be in the direction required. Herschel suggested the Eccentricity theory, but abandoned it. Adhémar's Precession theory, as explained by himself, involved an absolute fallacy. The celebrated view of Dr. Croll combines the Precession and Eccentricity theories into one. It exactly agrees with the Antarctic greater extension of ice, and provides an explanation of interglacial warm periods. The great difficulty in its way is to see how a mere difference in distribution through the year of an unchanged total heat-receipt can produce consequences so vast. The laws of radiation explain but a very minute part, the laws of evaporation perhaps rather more; but, so far as can at present be seen, both together are inadequate. Another serious objection is that the theory seems to require the climate of the northern hemisphere to be now in a state of change for the better, of which at present there appears no evidence. Dr. Croll's elaborate explanations of the reaction of one effect upon another—fogs, deflection of currents, and the like—have no special connection with his own theory. They would act in all cases, and support all theories equally. The arguments, if admitted, would only prove that the earth's climates are in a state of highly unstable equilibrium, in which a slight cause may produce an enormous change. Nor are his arguments universally admitted. In conclusion, Dr. Croll's theory seems inadequate: alteration of currents and winds are the most powerful causes suggested hitherto: further investigations ought to be made as to the nature and extent of the last series of changes in the outlines of the continents of the globe.

What is a Mineral Vein or Lode? by C. Le Neve Foster, B.A., D.Sc., F.G.S., H.M. Inspector of Mines.—The author quoted briefly the definitions of a mineral vein given by Werner, Carne, Von Cotta, Grimm, Von Groddeck, Geikie, Sandberger, and Serlo, who, in common with most geologists, have looked upon mineral veins as "the contents of fissures." While admitting that a very large number of veins may be so described, the author contended that the exceptions are sufficiently important and numerous to warrant a change in the definition. He is of opinion that many of the principal and most productive tin-lodes in Cornwall are simply tabular masses of altered granite adjacent to fissures; and he brought forward the opinions of other geologists to show that certain veins in the English Lake district, the Tyrol, Nova Scotia, Nevada, Colorado, California, and Australia, are not filled-up fissures. In conclusion, he proposed the following definition: "A mineral vein or lode is a tabular mineral mass formed, more or less entirely, subsequently to the inclosing rocks."

The Acadian Basin in American Geology, by L. W. Bailey, Geological Survey of Canada.—The Acadian Basin, embracing the region bordering on and including the Gulf of St. Lawrence, together with the provinces of New Brunswick, Nova Scotia, Newfoundland, and Prince Edward Island, constitutes one of the natural physical divisions of the continent of North America, and exhibits many marked peculiarities of climate and floral and faunal distribution. In its geological structure, and in the history which this reveals, its individuality is not less clearly marked, being often in strong contrast with that of other portions of the continent farther west; and in some periods and features even exhibiting a closer relationship with the geology of Europe. In the present paper, the facts bearing upon this individuality are summarised and discussed; including the consideration of the varying land-surfaces of Acadia in different eras, the time and nature of its physical movements, its climate, and its life. A review of recent progress in the investigation of its geological structure is also given.

Upon the Improbability of the Theory that former Glacial Periods in the Northern Hemisphere were due to Eccentricity of the Earth's Orbit, and to its Winter Perihelion in the North, by W. F. Stanley, F.G.S., F.R.Met.S.—The theory of Dr. Croll, accepted by many geologists, is that former glacial periods in the northern hemisphere were due to greater eccentricity of the earth's orbit, and to this hemisphere being at the time of glaciation in winter perihelion. This theory is supported upon conditions that are stated to rule approximately at the present time in the southern hemisphere, which is assumed to be the colder. Recent researches by Ferrel and Dr. Hann, with the aid of temperature observations taken by the recent Transit of Venus expeditions, have shown that the mean temperature of the southern hemisphere is equal to, if not higher than the northern, the proportions being 15·4 southern and 15·3 northern. The conditions that rule in the south at the present time are a limited frozen area about the South Pole, not exceeding the sixtieth parallel of latitude; whereas in the north frozen ground in certain districts, as in Siberia and North-Western Canada, extends beyond the fiftieth parallel; therefore by comparison the north, as regards the latitude in which Great Britain is situated, is at present the most glaciated hemisphere. As it is very difficult to conceive that the earth had at any former period a lower initial temperature, or that the sun possessed less heating power, glaciation in the north could never have depended upon the conditions argued in Dr. Croll's theory. The author suggested that glaciation within latitudes between 40° to 60° was probably at all periods a local phenomenon depending upon the direction taken by aërial and oceanic currents; as, for instance, Greenland is at present glaciated, Norway has a mild climate in the same latitude, the one being situated in the predominating northern Atlantic currents, the other in the southern. Certain physical changes suggested in the distribution of land would reverse these conditions and render Greenland the warmer climate, Norway the colder.

On the Occurrence of the Norwegian "Apatitbringer" in Canada, with a few Notes on the Microscopic Characters of some Laurentian Amphibolites, by Frank D. Adams, M.Ap.Sc., Assistant Chemist and Lithologist to the Geological Survey of Canada.—The paper first gives a short account of the investigations which have been made on this amphibole-scapolite rock in Norway, where all the principal deposits of apatite either traverse it or occur in its immediate vicinity. The deposits of apatite in Canada generally occur associated with some variety of highly pyroxenic rock, often holding orthoclase and quartz. The "Apatitbringer" has, however, recently been found in the

vicinity of the town of Arnprior on the River Ottawa. It closely resembles the Norwegian rock, both in external appearance and in its microscopic characters, containing hornblende, scapolite, and pyroxene as essential constituents. A number of amphibolites in the Museum of the Geological Survey of Canada, which resemble this rock in appearance, have been sliced and examined with the microscope, and one of them found to contain scapolite in large amount. It was collected at Mazinaw Lake, in the township of Abinger, and is from the same belt of hornblendic rocks as that in which Arnprior is situated. The paper closes with a short account of some of these amphibolites.

The Geological Age of the Acadian Fauna, by G. F. Matthew, A.M., F.R.S.C.—In this sketch an attempt is made, by comparison with the Cambrian fauna of other countries, and especially of Wales, to fix more exactly than has hitherto been done the position of the assemblage of organisms found near the base of the St. John group. The trilobites are taken as a criterion for this purpose. A brief statement of the position and thickness of the beds is given, showing the relation of the fauna to the formation as a whole. It is shown that the genera and species of the Acadian trilobites do not agree with those of the Menevian, in the restricted application of that term now in vogue; the great *Paradoxides* with short eyelobes, and the genera *Anopolenus*, *Agraulos* (= *Arionellus*), *Erinnys*, and *Holocephalina* being, so far as known, absent from it. On the other hand, it shows very close relationships in its genera to the Solva group fauna, especially in the following species:—

Solva Group	Acadian Fauna
Conocoryphe solvensis, Hicks	*Ctenocephalus matthewi*, Hartt sp.
Conocoryphe bufo, Hicks	*Conocoryphe elegans*, Hartt sp.
Paradoxides harknessi, Hicks	*Paradoxides cteminicus*, Matthew

As bearing on the question of the age of the Acadian fauna, the development of the eyelobe in *Paradoxides* is referred to, and it is shown that while in the Cambrian rocks of Wales the length of the eyelobe is in direct relation to the age of the strata, the *Paradoxides* of the Acadian fauna, having continuous or nearly continuous eyelobes, are more primitive in their facies than those of the Menevian, and agree with the species found in the Solva group. The family of Conocoryphidæ, restricting the name to such species as those described by Corda under *Conocoryphe* and *Ctenocephalus*, are a marked feature of this early fauna; and *Conocoryphe* has a characteristic suture not observed in the Menevian genera. The Acadian *Ctenocephalus* also differs in this respect from the Bohemian species.

On the More Ancient Land Floras of the Old and New Worlds, by Principal Dawson, LL.D., F.R.S.—In the Laurentian period vegetable life is probably indicated, on both sides of the Atlantic, by the deposits of graphite found in certain horizons. There is good evidence of the existence of land at the time when these graphitic beds were deposited, but no direct evidence as yet of land plants. The carbon of these beds might have been wholly from subaquatic vegetation; but there is no certainty that it may not have been in part of terrestrial origin, and there are perhaps some chemical arguments in favour of this. The solution of the question depends on the possible discovery of unaltered Laurentian sediments. The Silurian land flora, so far as known, is meagre. The fact that *Eopteris* has been found to be merely a film of pyrite deprives us of the ferns. There remain some verticillately-leaved plants allied to *Annularia*, the humble Acrogens of the genus *Psilophyton*, and the somewhat enigmatical plants of the genera *Pachytheca*, *Prototaxites*, and *Berwynia*, with some uncertain Lycopods. We have thus at least forerunners of the families of the *Arterophyllitea*, the *Lycopodiaceæ*, and the *Coniferæ*. The comparison of the rich Devonian or Erian flora of the two sides of the Atlantic is very interesting. On both continents it presents three phases—those of the Lower, Middle, and Upper Erian—and there is a remarkable correspondence of these in countries so wide apart as Scotland, Belgium, Canada, Brazil, and Australia. Examples of this were given in the Rhizocarps, at this period very important, in the Lycopods, the Equisetaceæ, the Ferns, and the Conifers. The number of coniferous trees belonging to *Dadoxylon* and allied genera, and the abundance of ferns, often arborescent, were especial features in the Middle and Later Erian. The flora of the Erian age culminated and then diminished. In like manner that of the succeeding Carboniferous period had a small commencement quite distinct in its species from the Erian; it culminated in the rich vegetation of the true coal formation, which was remarkably similar over the whole world, presenting, however, some curious local differences and dividing lines which are beginning to become more manifest as discovery proceeds. In the Upper Carboniferous the flora diminishes in richness, and the Permian age is, so far as known, one of decadence rather than of new forms. Great progress has recently been made by Williamson and others in unravelling the affinities of the coal-formation plants, and we are on the eve of great discoveries in this field. Throughout the Silurian the conditions do not seem to have been eminently favourable to plants, but the few forms known indicate two types of Acrogens, and one leading to the Gymnosperms, and there is no reason to doubt the existence of insular land richly clothed at least with the few forms of vegetation known to have existed. In the Erian and Carboniferous there seem to have been two great waves of plant-life, proceeding over the continents from the north, and separated by an interval of comparative sterility. But no very material advance was made in them, so that the flora of the whole Palæozoic period presents a great unity and even monotony of forms, and is very distinct from that of succeeding times. Still the leading families of the *Rhizocarpeæ*, *Equisetaceæ*, *Lycopodiaceæ*, *Filices*, and *Coniferæ*, established in Palæozoic times, still remain; and the changes which have occurred consist mainly in the degradation of the three first-named families, and in the introduction of new types of Gymnosperms and Phænogams. These changes, delayed and scarcely perceptible in the Permian and Early Mesozoic, seem to have been greatly accelerated in the Later Mesozoic.

On the Structure of English and American Carboniferous Coals, by Edward Wethered, F.G.S., F.C.S.—The author had examined several seams of coal from England and America. He pointed out that they were not always made up of one continuous bed of coal, but often comprised several distinct beds. In the case of the well-known Welsh "four-feet" seam there were four distinct strata of coals, separated by clay beds of a few inches thick. In the case of the "splint coal" from Whitehill Colliery, near Edinburgh, the seam presented three clearly-defined beds of coal, but these were not separated by partings of any kind. With a view of testing the "Spore theory" of the origin of coal, as propounded by Prof. Huxley, the author had obtained a portion of the "better-bed" seam intact for a thickness of 10 inches from the top. He had examined this inch by inch, by preparing thirty-three microscopic sections. At the top were $3\frac{1}{2}$ inches of dull lustrous coal, termed "laminated coal." This the author found to be practically a mass of macrospores and microspores. Below this there was a change in the character of the seam. Spores became less numerous; in places they were scarce, the mass being made up of vegetable tissue and a substance to which the author gives the term "hydrocarbon." He could not, therefore, support Prof. Huxley in saying that the "better-bed" coal was "simply the sporangia and spore-cases of plants." The assertion would, however, apply to the first $3\frac{1}{2}$ inches of the seam. The "splint coal" from Whitehill Colliery was a better example of a spore coal than the "better-bed." The bottom stratum was 4 inches thick, and presented a dull lustre, with thin bright layers traversing at intervals. The dull portion was a mass of spores and spore-cases, but these did not enter the bright layers. A vertical section cutting a bright layer, bounded on either side by dull lustrous coal, showed plenty of spores in the dull coal, but in the bright not one was detected. The second bed in this seam was 1 foot thick; it was of a brighter lustre than the 4 inches below, but two layers could be distinctly made out, one more lustrous than the other. In the dullest of the two, spores were found, which, however, were less numerous than in the bed below, and were also of a different variety. In the bright layers the spores were absent. The top bed of the seam was also 1 foot thick, and might be defined as a mass of spores, chiefly microspores, except in the bright layers. The American coals examined were collected by the author from the Warrior Coalfields of Alabama, and from near Pittsburg, Pennsylvania. The same structural affinities were noticed as in the English coals, and the author therefore came to the conclusion that the English and American Carboniferous coals had a common origin. The spores in the coal from both countries were closely allied. Some microspores from Alabama were identical with those which occur in the lower bed of the Welsh "four-feet" seam. A feature in spores obtained from all the coals was the triradiate markings which they exhibited. Whether this was to be regarded as superficial or not, it was very characteristic of them, and was therefore to be considered in attempting to ally them with modern vegetation. The

author regarded peat in the light of post-Tertiary coal; lignite as peat in a transition state to coal; and coal as the remains of Carboniferous bogs. The author referred to the practical application of a knowledge of the microscopic structure of coal, as enabling an expert to judge of the nature of a coal from an examination of it with a pocket lens.

Points of Dissimilarity and Resemblance between Acadian and Scottish Glacial Beds, by Ralph Richardson, F.R.S.E., V.P. G.S.Edinb. — Mr. Richardson said that, in his "Acadian Geology," Principal Dawson gave the following as a typical section of the superficial geology of Acadia—that is, Nova Scotia, New Brunswick, and Prince Edward Island—and as, in some respects, also applicable to Canada and Maine, viz.: At the bottom, peaty deposits; then unstratified Boulder Clay; then stratified Leda Clay, indicating deep water; and, lastly, gravel and sand beds, the Saxicava sand indicating shallow water. Mr. Richardson pointed out wherein such a section differed from and resembled the glacial beds of Scotland. He said the latter showed no such orderly arrangement as the Acadian, and could not, as a rule, be divided into deep and shallow water-beds. The marine shells in the Scottish beds are all mixed up together, regardless, as a rule, of the province—whether Arctic or British, or both—to which they properly belong, regardless of the depths which they usually tenant, and regardless of the deposit (whether clay, gravel, or sand) in which they are now found fossil. They are likewise met with at all heights, from the level of the sea to more than 500 feet above it. No system of dispersion of boulder-erratics from definite centres in Scotland seems as yet ascertained. The peaty deposits, occurring in Principal Dawson's section *below* the Boulder Clay or till, occur in Scotland above it. With regard to points of resemblance, the facies of the shells in Acadia and Scotland is similar, being of the Arctic and British-Arctic type. Again, both in Acadia and Scotland, all the fossiliferous glacial beds occur above the unstratified Boulder Clay or till. Mr. Richardson cited various Scottish sections to prove this, and remarked that the belief in earlier and later Boulder Clays is of long standing in Scotland. He concluded by pointing out that, in their cardinal features, the Acadian and Scottish glacial beds seemed to coincide. In both Acadia and Scotland that great mass of unstratified clay known as *till* existed; and doubtless the geologists of the New World were, like those of the Old, puzzled to account for its origin with certainty and satisfaction. The question was left unsolved by the meeting of the British Association in Edinburgh in 1850; although then discussed by Hugh Miller and Prof. John Fleming. The author hoped that during the present meeting some advance would be made in solving this great problem, as well as in correlating and arranging the glacial beds of Canada, Acadia, and Britain.

On the Mode of Occurrence of Precious Stones and Metals in India, by V. Ball, M.A., F.R.S.—For full 3000 years India has been known as the source of precious stones and metals, but scarcely 200 years have elapsed since other countries yielding precious stones have entered into competition with her; and it is only within the present century that she has ceased to hold a pre-eminent position as a supplier of the markets of the world. In order to arrive at a full and satisfactory elucidation of this subject, two branches of inquiry must be undertaken—one based upon what has been actually ascertained by careful geological exploration of the country, and the other upon such historical records as are available of the former production of the minerals in question, and of the indications of the sites where they were mined. By means of our present knowledge of the geology, it has become possible to give definite form to many vague statements by early writers, and to recognise the actual positions of mines which are now, by the people of the localities themselves, forgotten and deserted. In the majority of these cases, had the geologist not got the historical hand to guide him, he would be unwilling to predicate the presence of such minerals from mere superficial examination. As a collateral result, many of the widespread myths and fables connected with mining have proved to have originated in peculiar local customs. They rest, therefore, on more substantial bases of facts than could have been suspected by any one unacquainted with these customs. This method of combining the results of geological research with historical records the author has found on previous occasions to have the advantage of bringing the geologist into touch with the rest of humanity, arranging as it does the interest of historians, linguists, and others, who find in the facts so presented to them pabulum applicable to the requirements of their own particular pursuits. In this paper it will not be necessary or suitable to enter at length into details—the author having done so elsewhere.[1] His object is rather to direct attention to the subject generally, and to make known the fact that much has been accomplished of late years which has not as yet found its way into manuals and encyclopædias. Most of the information to be found in such works is far behind our present knowledge; and, where not actually incorrect, has been superseded by fuller and more accurate observations. The subjects taken for special consideration are the following:—Diamond, ruby, sapphire, spinel, beryl, emerald, lapis-lazuli, gold, silver. The steel of India, or *wootz*, might be included here, since, at least 2000 years ago, it was one of the most precious productions of India.

On the Relative Ages of the American and the English Cretaceous and Eocene Series, by J. Starkie Gardner, F.L.S., F.G.S.—The paper is a contribution towards the determination of the ages of the American Cretaceo-Eocene rocks, relative to those of Europe. It briefly describes the chief characteristics of the various stages of the series in America. The lowest beds there are distinguished by the presence of well-developed dicotyledonous leaves, associated with *Ammonites* and other Cretaceous Mollusca, considered to warrant their correlation with the Gault and Chalk of England. Newer beds thought to be intermediate in age between Secondary and Tertiary are distinguished by the incoming of palms and a new flora of Dicotyledons, associated with *Mosasaurus*. The rest are correlated with the various divisions of the Tertiary series recognised in Europe. The entire series seems to have been deposited without any considerable break in continuity, but reveals a sudden transition from a temperate to a subtropical flora, and from a Cretaceous to a Tertiary Vertebrata. The high development of the flora is, however, quite irreconcilable with the accepted correlation. In further comparing the American series with that of Europe, it is observed that the subdivisions of the Cretaceous series were first determined for a limited area, when different ideas of evolution and gradual passage prevailed, and subsequently extended to embrace areas at a distance which may be, rightly or wrongly, correlated with those of England and Western France. The comparisons now drawn are only between the rocks of the original and typical area and of America, excluding the Cretaceous rocks of other countries. Thus restricted, the Neocomian of Europe comprises only shore deposits, characterised by a Cretaceo-Jurassic fauna and a Jurassic flora. The Gault is a deeper sea-deposit, comparable to the "Blue Mud" of the *Challenger*, with a typically Cretaceous fauna and a Jurassic flora. The Upper Greensands are more or less the equivalents of the Gault, deposited under differing physical conditions, corresponding to the "Greensands" of the *Challenger*, and have been assumed to represent the shore or shallower water conditions preceding the Chalk. The Chalk itself is described with a view to prove that it is a truly oceanic deposit, formed at a distance from shore and at a considerable depth, corresponding in all respects with the existing "Globigerina Ooze." The arguments against this view are refuted in detail, and the suggestion made that the alleged shallower habitats in the tropics of the few surviving Mollusca may be due to the lower temperature prevailing now in the abyssal depths of the ocean having driven heat-loving types from the depths at which they were able to live in the Chalk period. The whole Cretaceous series in the British area is the result of a gradual conversion of land into sea, owing to subsidence. The process commenced with the Neocomian, became more serious with the Gault, and continued until the close of the Chalk. The focus of the depression, so far as its results are accessible, was the English Channel, whence it spread in an easterly direction across Central Europe. As the land subsided, the gulf increased in magnitude, and Blue and Green Muds were formed on a wider and wider area, to be succeeded in due time by chalky Ooze. The nearer the focus of subsidence the older the Greensands and Gault, and the farther we recede from it the newer in age they become. The zones of increasing depth travelled outward and forward, and though now represented by continuous bands of the same lithological characters, extending over many countries, it would be rash in the extreme to infer the synchronism of portions of these when separated by degrees of latitude. The time required for these zones to travel from Kent to the Crimea, and to accumulate a mass, mainly composed of minute organisms, of over a thousand feet in thickness, must have been sufficient to account

1 "Economic Geology of India," and "A Geologist's Contribution to the History of India," *Proc. Roy. Dub. Soc.* 1883.

for a very sensible progress in the evolution of organic forms. The deposition of the Chalk commenced in the English area at a period when the land floras were still of Jurassic character. By the time it had reached Limburg, Saxony, and Bohemia, Dicotyledons had become developed. The period required for the chalk ocean to encroach but 300 to 400 miles must thus have been very vast. The question may, however, arise whether plant development at this stage followed the otherwise universal law of evolution, or was exceptionally rapid. The fauna has to be examined to see whether it discloses an equally appreciable progress. The conclusion arrived at is that while the groups with which the author is less acquainted apparently do so, the progress in the Mollusca is unmistakable. The helicoid, turbinate, and patelloid groups are archaic and stationary, but the fusiform shells betray a tendency to elongate their canals, and the relative abundance of such, and gradual dropping out of now extinct genera, furnish an unmistakable index of the relative ages of the more littoral deposits. From this point of view we are able to demonstrate that the Greensands of Aix-la-Chapelle are far younger than their lithological structure and sequence would indicate, while the appearance of such distinctly new developments as cone and cowry shells further support the views of the relatively almost Tertiary, or, at least, transition, age of the Cretaceous series in Denmark. While, therefore, denudation on a truly colossal scale has produced one of the most considerable gaps in the whole geological record between Cretaceous and Tertiary over the British area, beds of intermediate age may successfully be sought for at a distance from this centre. The erroneous correlation of these, bed by bed almost, with the typical Cretaceous series, as developed in England, has led to a still more untrustworthy correlation of the American series with ours. The Cretaceous series of America contains at its very base a flora composed of angiosperms so perfectly differentiated that they are apparently referable to existing genera. One of the oldest floras in Europe containing angiosperms is that of Aix-la-Chapelle, and even this we have seen is relatively modern ; but these are not referable in at all an equal degree to existing genera, and even the Coniferæ are embarrassing on account of their highly transitional characters. The oldest Cretaceous flora of America, so far from possessing any Cretaceous characters, agrees in a remarkable manner with that of the English Lower Eocene, while the Laramie, or supposed Cretaceo-Eocene, flora has very much in common with that of our Middle Eocene, and marks a similarly sudden rise in temperature. The question is whether the evidence of the fauna in favour of the Cretaceous age of the series is so conclusive that the floral evidence must be set aside. Taking the Cretaceous series as represented in California, the older stages possess Mollusca of definitely Cretaceous aspect, but those of the newest have a decidedly Eocene facies. To be Cretaceous a fauna must have some elements which did not survive to a later period ; but are we in a position to state that the Ammonitidæ, the Belemnites, and Inocerami did not do so ? Even our present limited knowledge is entirely opposed to such a view. It must be remembered that the Eocenes in their typical area, England and France, were deposited under peculiar local conditions, and it would be as logical to infer from the absence in them of Cretaceous types that these existed nowhere else as it would be were the bed of the English Channel now upheaved to class as extinct all forms of life not met with in its sands and muds. If, as there is evidence to show, America was isolated at the time, the survival there of forms of Reptilia elsewhere extinct would be in accordance with ordinary observation at the present day. The flora of the American series is Eocene ; the fauna of its earlier stages is Cretaceous. We are compelled therefore to choose whether we will believe that a large Eocene flora was developed there during the Cretaceous, or that some members of a Cretaceous fauna lived on to an Eocene date. The former supposition demands greater rapidity of evolution than we are accustomed to admit, and no external evidence is advanced to support it. The latter is more conceivable from the standpoint of evolution, and is not contradicted by any evidence that has yet come under the author's observation.

On Some Remains of Fish from the Upper Silurian Rocks of Pennsylvania, by Prof. E. W. Claypole, B.A., B.Sc. (London), F.G.S., of the Second Geological Survey of Pennsylvania.—The earliest vertebrate animals yet known from any part of the world are some remains of fish in the Upper Silurian rocks of England. They are for the most part of three types. First, short fin-spines, named by Agassiz *Onchus tenuistriatus ;* second, fragments of shagreen, or the skin of a placoid fish (*Thelodus* and *Sphagodus*), belonging probably to the same that carried the spine ; and third, ovate, finely striated plates or shields, supposed to be the defensive armour of some fish, unlike any now living. No one has doubted the ichthyic nature of the first and second of these three forms. But as regards the third there has been much controversy. Evidently allied to *Cephalaspis*, its right to the name of fish has been called in question, and suspicion has been raised in regard to the whole family of the Cephalaspids. On the whole, however, it seems best to retain them in the class of fishes, and to this conclusion Prof. Huxley evidently inclines in the conclusion of his "Essay on the Classification of the Devonian Fish." One may expect some, or even considerable, divergence of structure from the usual ichthyic types in such early forms. These English fossils occur in the lowest beds of the Devonian (Cornwall), and in the highest beds of the Silurian (Shropshire and Hereford). The well-known Upper Ludlow "bone bed" has yielded them in considerable quantity, and one specimen is reported by Sir C. Lyell in his "Elements of Geology" (1865) as discovered from the Lower Ludlow, beneath the Aymestry limestone. Below this horizon I have never heard of their occurrence. The English Ludlow, taken as a whole, has been usually correlated with the Lower Helderberg of North America, and on good grounds, both containing *Eurypterus* and *Pterygotus*. The English Lower Ludlow and the Water-Lime or basal beds of the North-American Lower Helderberg are the lowest strata containing these fossils. On both sides of the Atlantic they range from this level upwards into the Devonian. The oldest vertebrate fossils yet announced from America are those found in the Corniferous limestone or Lowest Devonian of Ohio. Possibly the beds at Gaspé, on the Gulf of St. Lawrence, are somewhat lower, as they have yielded *Cephalaspis*, which is not yet known from Ohio, and *Coccosteus*, of which Ohio has yielded only a single specimen. No authenticated fish-fossil has yet been announced from the Upper Silurian rocks of America. It is true that reports of the discovery of such remains have been published at various times, but investigation has proved them all erroneous. (See "Palæontology of New York," vol. ii. pp. 319, 320, pl. lxxi. ; *American Journal of Science*, second series, vol. i. p. 62 ; "Palæontology of Ohio," vol. ii. p. 262.) During my recent work on the palæontology of Perry County, Pennsylvania, I came upon some fossils which at once suggested relationship to the Ludlow group above described. Among them were a few spines recalling *Onchus tenuistriatus*, but with some differences. I have named them *Onchus pennyslvanicus*. With them I discovered abundance of specimens bearing a strong resemblance to *Pteraspis*, but larger, and differing in some other respects. These I name *Glyptaspis* (*G. elliptica* and *G. bitruncata*). Comparing these with *Pteraspis* we find them much thinner, not exceeding one-tenth of an inch in thickness ; whereas specimens of *Pteraspis* in my possession from Cornwall are nearly one-fourth of an inch thick. The striation on both is equally fine, but is rather less regular on the American specimens. These also show no trace of the spine in which the shield of *Pteraspis* terminates, as shown by Murchison in "Siluria." No traces of the English fossil shagreen—*Thelodus* and *Sphagodus*—have been found in the Pennsylvanian beds, though it abounds in the Ludlow rocks. The fossils were found in a bed of sandstone about 200 feet below the base of the water-lime in Perry County, Pennsylvania, near the top of the great mass of variegated shale composing the Fifth Group of Rogers in the First Survey of Pennsylvania. This shale in New York immediately overlies the Niagara limestone, which is correlated on satisfactory evidence with the Wenlock limestone of England. Ten or twelve species are common to the two beds. It seems, therefore, that the great mass of coloured shale, near the top of which these fossils were found, and which is a continuation of the Onondaga group of New York, has no representative in the British series, but corresponds to an interval between the Upper Wenlock and the Lower Ludlow. (For details regarding the correlation of these beds in Pennsylvania with those in New York, see a paper by the author in *Proc. Amer. Phil. Soc.* for 1884.) It is consequently a necessary inference that the beds yielding *Glyptaspis* and *Onchus* in Pennsylvania are somewhat older than those containing *Pteraspis* and *Onchus* in England. Microscopic examination of the specimens, and a comparison of their structure with that of *Pteraspis* and *Cephalaspis* are in progress, and the details will be given in the paper. Other fossils in the author's possession indicate the possible existence of fish at a still earlier date, but the material is not yet worked out.

On Fluxion-Structure in Till, by Hugh Miller, A.R.S.M., F.G.S., Geological Survey of England and Wales.—It has long been recognised as one of the characteristics of the till that its long-shaped boulders are striated lengthwise. They have, as it has been concisely expressed, been "launched forward end-on." From the minute and magnifiable striæ upon the smaller (*e.g.* almond-sized) boulders it also appears that these at least have been carried forward, involved in the matrix, and were glaciated chiefly by its particles. Under the microscope these particles exhibit most of the varieties of form and glaciation that are found among larger boulders. The structure of the till in open situations shows that the axes of its stones have been turned by a common force in the direction of glaciation; it exhibits a rough structure comparable to the fluxion-structure of igneous rocks, the smaller boulders dividing around and apparently drifting past the larger, like the tide round an anchored skiff. These structures, which have been found by the author over many hundreds of square miles, chiefly in the north of England, indicate that at least a surface-layer of the till was dragged along, with a shearing movement of particle upon particle, producing intimate glaciation within its mass. Proofs are adduced that this moving layer was in general a surface-layer only, and that the till did not, as has often been supposed, move forward *en masse*, licking up its additions from beneath. This is the only intelligible explanation of the order (as well as the structure) of the boulder-clays of which the author has any practical knowledge. In up-lying situations, where the drift consists of raw material, fluxion-structures are seldom detected. In sheltered spots they are not generally developed. They are characteristic of well-kneaded till in open situations, liable, however, to obscuration by contortions within the mass. Of twelve experimental attempts made near the watershed of England in East Cumberland, 600–900 feet above the sea, to determine the ice-movement from this structure alone, eight were correct, three indeterminate, and only one misleading. The pressure and movement capable of producing this widespread fluxion-structure seem to have been that of some mass vast and far-spreading—closely investing, slow-moving, and heavily dragging—such as glacier ice. It needs only to be assumed that the confluent glaciers communicated something of their own movement and structure to the ground-moraine below.

On the Southward Ending of a Great Synclinal in the Taconic Range, by James D. Dana, LL.D.—The Taconic Range, which gave the term "Taconic" to geology, lies in Western New England, between Middlebury, in Vermont, on the north, and Salisbury, in Connecticut, on the south. In former papers, published in the *American Journal of Science*, the author has shown, first, that the rocks constituting the range vary as we go from north to south, from roofing-slate and hydromica (or sericite) schist to true chloritic and garnetiferous mica schists; secondly, that these schists lie mostly in a synclinal or compound synclinal; thirdly, that the crystalline limestone along the eastern foot is one with that along the western, the limestone passing under the schist as a lower member of the synclinal; and fourthly, that since the limestone contains in Vermont (according to the discoveries of the Vermont Geological Survey, and also of Mr. A. Wing), and in the State of New York, fossils of the Lower Silurian, ranging from the inferior divisions to the higher, the Taconic schists are probably of the age of the Hudson River group or Llandeilo flags. The author's papers further show that while a large part of the Taconic Range has eastward dip on both the east and west sides, a southern portion about twelve miles long, consisting of Mount Washington in south-western Massachusetts and its continuation into Salisbury, Connecticut, is a broad tray-shaped synclinal, the dips of the two sides being toward one another, like the sides of an ordinary trough. The width of the broad synclinal between the limestone belt on either side is about five miles. As the result of investigation during the last two years, the synclinal character of this Mount Washington part of the Taconic Range is illustrated in the paper by new sections, and by facts connected with the dying out of the great synclinal (or compound synclinal) in the town of Salisbury. The mean height of Mount Washington above the sea-level is about 2000 feet, and above the wide limestone region on either side and to the south, about 1250 feet. The synclinal virtually ends along an east and west line through the village of Lakeville, in the town of Salisbury, where a beautiful lake lies within the limestone area. The surface of the mountain region descends 1000 feet in the southern, or last, three miles; and in the latitude of Lakeville, the width, as the map presented shows, diminishes abruptly from five miles to a narow neck of six-tenths of a mile. The area south is of limestone, and the neck of schists referred to is hardly 150 feet in height above it. The limestone may in some places be seen emerging from beneath the schist at a small angle; and at one locality a low oven-shaped anticlinal of limestone has the schist covering all but a narrow portion at top; the quarrymen had to remove the schist to work at the limestone. Several narrow strips or belts of limestone, S. 15° W. in direction, corresponding with the direction of this part of the range, show out through the sides of the mountain where local anticlinals have had their tops worn off. Further, the dip of the schist over much of the southern slope is southerly and at a small angle, but with many local anticlinals and synclinals. In addition, there are small areas of schist *in the limestone* region, like straggling portions of the dwindled mountain, which appear in general to be remains of local flexures. There is the plainest evidence that the limestone formation of southern and south-eastern Salisbury comes out from beneath the dwindled, flattened-out, and worn-off mountain synclinal. And the reason why this limestone is exposed to view over plains miles in width, east and west of the Taconic Mountain, as well as to the south, is simply this, that the once overlying schist has been removed because in badly broken anticlinals and synclinals. The paper closes with an allusion to the orographic, stratigraphical, and lithological interest of the facts, and to their important bearing on the question of the origin and chronology of certain kinds of crystalline rocks, such as chloritic, garnetiferous, and staurolitic mica schists, as well as others less coarsely crystalline.

The Primitive Conocoryphean, by G. F. Matthew, A.M., F.R.S.C.—Relates to the development of the species *Ctenocephalus matthewi* and other Conocorypheans of the Acadian fauna, and is considered under the three heads, viz., the Development of the Glabella; the Acquisition of Sensory Organs; and the Decoration of the Test. Under the first head it is shown that the peculiar glabella of the species above referred to is closely related to the early history of the trilobite. The glabella, in its earliest stage, is very different from that of the adult, and in outline is not unlike that of *Paradoxides*; it also resembles this species in the position of the ocular fillet. At the next stage the glabella or axial lobe becomes trumpet-shaped, as in *Carausia*, and in the third the glabella proper is developed by the segmentation of the axial lobe: the glabella and ocular fillets now resemble those of *Ptychoparia*. In the following stages the family characters of the Conocorypheans begin to assert themselves, especially the widening of the base of the glabella, the appearance of the canals connected with the ocular ridges, and the development of spines. (2) *The Acquirement of Organs of Sense*.—The ocular fillet appears, in the second stage of growth, as a faint, narrow ridge, close to the anterior marginal fold, and extending but a short distance from the glabella. It is not until the fifth stage of growth that the ramifying branches which spread from the ocular ridge to the anterior margin made their appearance. The ocular lobe and sensory apparatus connected with it are more distinctly visible on the under than on the outer surface of the test, and the canalets connected with the lobe spread over the anterior slopes of the shield, and extend to the anterior margin. In the tuberculated species they connect by hollow spines with the outer surface. In one species they cover a wider space than in the others, extending some distance behind the ocular ridges and over the front of the glabella. (3) *Decoration of the Test*.—In all the Acadian species of this group but one, the surface of the test at maturity is covered with tubercles and spines similar to the surface-markings of *Conocoryphe sulzeri*, &c. In the earliest stages, however, no such tubercles are found, but the surface appears smooth or scabrous. In *Ctenocephalus matthewi* the surface, in the first three stages of growth, appears smooth; in the fourth, tubercles begin to appear, and about the fifth stage all projecting parts of the test are studded with them. Those on the glabella and frontal lobe are arranged in transverse rows, those on the cheeks in interrupted rows conforming more or less to the periphery of these protuberances. Towards the adult stage these tubercles and spines become more irregular in position and number, conforming in this respect to the law of development in the Ammonites, expounded by Prof. Alphonso Hyatt.

The Value of Detailed Geological Maps in relation to Water-Supply and other Practical Questions, by W. Whitaker, B.A., F.G.S., Geological Survey of England.—Those maps of the Geological Survey of England in which various divisions of the

Drift have been coloured tell us, as a rule, a very different tale from the corresponding sheets in which the Drift is ignored, and it is only these Drift maps that really give us a true idea of the nature of the surface. Indeed in many districts a geological map that does not show the Drift is comparatively useless for most practical purposes, at all events in a populous country like England. Moreover, it is not merely enough to mass Drift as such, but its constituent members should be fairly distinguished, not merely with regard to their classification or relative age, but also as to their composition, whether of clay, loam, or gravel and sand. To illustrate this there are exhibited copies of the two versions of many of the Geological Survey maps of the London Basin, with and without Drift, from which the following important points will be at once seen :—(1) Large tracts, shown as Chalk on one version, really consist, at the surface, of the generally impervious Boulder Clay, whilst over others the Chalk is covered by Brick-earth and Clay-with-flints : all these beds being such as give an aspect to the country very different to what we find where the Chalk is bare. (2) Parts of the wide-spreading area of the London Clay (of the Driftless maps) are really quite altered and deprived of their clayey character, by the sheets, long strips, and more isolated patches of gravel and sand that occur so often, whether along the river-valleys or over the higher plains. (3) The sandy, permeable Crags are in great part hidden by Drift, which, though often consisting of sand and gravel, is sometimes of Boulder Clay. Indeed, so widespread is the Glacial Drift in the greater part of Norfolk and Suffolk, that only a Drift edition of the Geological Survey maps of the eastern parts of those counties has been issued ; a map without Drift would necessarily be a work of fiction. To illustrate the important bearing which these Drift maps have on a great question, that of water-supply from the Chalk, the author also exhibits some special maps, which he has made to show the areas over which rain-water has access to the Chalk, as distinguished from those over which the surface-water cannot sink down into the Chalk, or can only do so very partially. These maps will be more particularly noticed in Section G.

Pennsylvania before and after the Elevation of the Appalachian Mountains, by Prof. E. W. Claypole, B.A., B.Sc., F.G.S. Lond.—The paper, of which the following notes are an abstract, is intended as an attempt to handle, in a necessarily imperfect manner, and only to first approximations, a difficult but important and interesting geological subject. The method of treatment is, in the writer's opinion, one that has not hitherto been employed for the same purpose. The object in view is to form some estimate, as near to the truth as possible, of the amount of compression or shortening produced at the surface by the corrugation of the upper layers of the coast into mountain chains, with especial reference to the American Atlantic seaboard. In order to confine the paper within due limits, certain propositions must be taken as proved. The principal of these are :—(1) That central contraction has developed tangential pressure in the crust ; (2) that the tangential pressure has produced crumpling of the crust ; (3) that to this crumpling are due long ranges of mountains ; (4) that the Appalachian Mountains came into being in this manner in the later portion of the Palæozoic era. These admitted, the conclusion necessarily follows that during the formation of the Appalachian Mountains a considerable contraction of the crumpled area ensued, in a direction at right angles to that of the chain. The following points constitute the main features of the paper :—(1) Short account of the great ranges of Pennsylvania, in plan and section, with diagrams ; (2) situation and account of the line of section adopted ; (3) limitation of the field to a consideration of eleven great ranges—Blue Mountains, Bower Mountains, Conecocheague Mountains, Tuscarora Mountains, W. Shade Mountains, Black Log Mountains, Blue Ridge Mountains, Jack's Mountain, Standing Stone Mountains, Tussey Mountains, Bald Eagle Mountains ; (4) Discussion of the different parts of this section—(*a*) the Mountain Region, (*b*) the Cumberland Valley ; (5) attempt to estimate or measure the curved line of the crumpled Upper Silurian (Medina) sandstone ; (6) inference that the sixty-five miles of the line of section represents about 100 miles of surface previously to the crumpling of the crust and elevation of the mountains ; (7) this result, for several reasons, below rather than above the truth ; (8) geographical effects of this contraction ; (9) development of the fact that such elevation of mountains by tangential pressure involves not only elevation, but considerable horizontal movement ; (10) diminution of motion to north-west ; (11) a few words on the failure of attempts yet made to account for this contraction ; (12) suggestions and conclusions.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE

At King's College Prof. W. Grylls Adams, F.R.S., will deliver a course of lectures on Electricity and Magnetism and their applications to Electric Lighting, Transmission of Power, &c., during the academical year 1884-5. A course of practical work in electrical testing and measurement, with especial reference to electrical engineering will also be carried on under his direction in the Wheatstone Laboratory. The lectures will be given once a week—on Mondays at 2 p.m.—and the Laboratory will be open on Wednesdays and Fridays from 1 to 4.

SOCIETIES AND ACADEMIES

Paris

Academy of Sciences, September 15.—M. Rolland, President, in the chair.—Address delivered at the inauguration of the Fresnel Monument at Broglie, by M. Jamin.—Remarks on algebraic equations, in connection with a communication from M. de Jonquières on the application of geometry to algebra, by M. Léon Lalanne.—Note on the two methods, proposed by Hamilton and Sylvester, for resolving the linear equation in quaternions, by Prof. Sylvester.—On the composition and properties of the light emitted by insects of the Pyrophore genus, by MM. Aubert and Raph. Dubois. Examined under the spectroscope, the spectrum of this light appeared very beautiful, continuous, and destitute alike of very bright and dark bands. It occupied about seventy-five divisions of the micrometer, extending on the red side to the centre of the interval separating the A and B rays of the solar spectrum, and on the side of the blue a little beyond the F ray. When its intensity diminishes, the red and orange disappear altogether, the spectrum being then reduced to the green with a little yellow and red, the green persisting longest. The reverse takes place when the insect begins to glow. Thus the least refrangible rays are the last to be emitted, a result hitherto observed in the spectrum of no other luminous body, except to a limited extent in that of the sulphide of strontium. Examined to ascertain its photo-chemical properties, this light showed a feeble display of the phosphorescence of the sulphide of calcium.—Remarks on a singular case of deformation in the images observed through telescopes, by M. Govi.

Berlin

Physiological Society, August 1.—Dr. A. Auerbach had made experiments to ascertain which of the constituents of flesh exercised the acid, alkali-abstracting effect on the blood witnessed in the reaction of the urine of flesh-eating animals compared with that of the urine of plant-eating animals. He found that the acid phosphoric potash increased the ammoniacal contents of the urine in a manner similar to that of the administration of acids. A dog fed on flesh having been brought into nitrogenous equilibrium, and kept in this state for some days, had a portion of acid phosphoric potash given to it in addition to the meat. The nitrogenous excretion remained the same as before, but the quantity of secreted ammonia had considerably increased, and this increase continued for some days after the dog was put back to the former flesh diet without the salt. The quantity of secreted ammonia corresponded, to the utmost nicety, with the quantity necessary for the conversion of the salts which had been taken, PO_4KHH, into PO_4KNO_4H.—Prof. Kronecker gave a report of a series of experiments conducted during the session now ended in the department of the Physiological Institute under his care. He first recounted the experiments of Mrs. Dr. Boll, who investigated whether asphyxiated fishes could recover animation without a supply of oxygen, and simply by withdrawing the carbonic acid from them. Goldfishes were left in boiled water free of air till the symptoms of asphyxia became distinctly manifest, and then a somewhat diluted caustic lye was added to the water without the admission of air. In every such case the fishes soon recovered their lively movements, and swam about freely in the water. It might therefore be concluded that, with the discharge of the surplus of carbonic acid, the symptoms of asphyxia would also disappear.—Prof. Kronecker then reported on the experiments of Dr. Kranzfeld, which had for their subject the movements of the stomach. In the stomach of each of the animals examined, the cardiac part, the pyloric part, and the middle had to be discriminated. Of these three parts the last was in most cases immovable, while the two other parts displayed lively movements. In the act of